Biology > Big idea BCL: The cellular basis of life > Topic BCL1: Cells > Key concept BCL1.4: Diffusion and the cell membrane

Response activity
Modelling diffusion

Overview

Learning focus:	Molecules move through the cell cytoplasm by diffusion, and some molecules can enter and leave a cell by diffusing through the cell membrane.
Observable learning outcome:	Explain diffusion as the net movement of particles from an area of their higher concentration to an area of their lower concentration.
Activity type:	Modelling, role play
Key words:	diffusion, particle, net movement

This activity can help develop students to explore and build explanations of diffusion at the particle level using role play, physical models and discussion. It can be used in response to the following diagnostic question:

- Diagnostic question: Deodorant

What does the research say?

Students can struggle to understand and explain diffusion because of the need to visualise and think about the process at the molecular/particle level (Sanger, Brecheisen and Hynek, 2001). Johnson (1998) summarises research in which it was found that even students who appreciate that a substance is made up of particles showed very little appreciation of the intrinsic, random movement of particles.

Odom (1995) has defined a list of knowledge statements required for understanding diffusion in the context of cells, which includes the following ideas:

1. All particles are in constant motion.
2. Diffusion involves the movement of particles.
3. Diffusion results from the random motion and/or collisions of particles (ions or molecules).
4. Diffusion is the net movement of particles from an area of high concentration to an area of low concentration.

Various researchers (Odom, 1995; Tomažič and Vidic, 2012; Stains and Sevian, 2015; Oztas and Oztas, 2016) have described common misunderstandings about diffusion in school children that can persist in students up to university level, including that:

- molecules move only in one direction, from an area of higher concentration to an area of lower concentration (a failure to understand the random movement of particles versus the concept of *net* movement);
- movement of particles stops after the concentration gradient between two areas has been equalised by diffusion (possibly because students interpret “no net movement” to mean “no movement of particles”);

- diffusion of a substance through a solvent requires a chemical reaction, or occurs because the substance splits up into smaller bits that mix with the solvent.

Some students believe that diffusion requires an external force or mechanical event (rather than resulting from the intrinsic movement of particles), a misunderstanding that may be linked to students' everyday experiences of stirring and dissolving, such as stirring sugar into tea (Çalýk, Ayas and Ebenezer, 2005; Stains and Sevian, 2015).

A number of researchers have described constructivist approaches that enable students to build their own explanations of diffusion, which may help to develop students' understanding and overcome misconceptions, including use of role play and physical models (Krajšek and Vilhar, 2010; Haddad and Baldo, 2010; Winterbottom, 2011; Kutzner and Pearson, 2017).

Ways to use this activity

Model 1 – role play

Students model diffusion by role playing as the particles/molecules of a substance. Winterbottom (2011) suggests clustering students in one corner of the room and asking them to role-play diffusion, and notes that usually they all walk away from the corner leaving an empty space. Follow this with a teacher-led discussion about why this behaviour is not a good model of diffusion; if necessary, prompt to draw out ideas about the random movement of particles in all directions, and about changes in direction after collisions with other particles.

The direction in which each student/particle moves at the start and following each collision could be decided at random by flipping a coin (Haddad and Baldo, 2010; Kutzner and Pearson, 2017).

Model 2 – physical model

To enable students to build an understanding of diffusion as resulting from the random nature of the movement of particles, a simple physical model such as black and white balls in a tray can be used Winterbottom (2011). Start with the black and white balls at opposite ends of the tray to simulate a concentration gradient, and then gently shake the tray. Ask students to watch an individual ball as the different coloured balls spread out and mix; the path taken by any individual ball will be random and not always in the direction of the concentration gradient; however, the *net* movement should be of white and black balls towards the opposite ends of the tray.

This could be done as a teacher demonstration or by students in pairs or small groups. The focus of the activity should be on observation and discussion of what is happening. It is through the discussions that students can check their understanding and develop their explanations.

Care must be taken to ensure that the shaking does not to introduce or reinforce the misunderstanding that diffusion requires an external force or mechanical event (rather than resulting from the intrinsic movement of particles). Make it clear to students that this is just a model, and in the real world particles move on their own.

Equipment

For each student/pair/group:

- coin or random number generator (optional)
- tray
- two different colours of balls (e.g. black and white)

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